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COATING BLADE AND METHOD OF PREPARING SAME

The present invention relates to coating blades for the application of coating colours onto travelling webs, and the invention also involves a method of preparing such coating blades.

Background of the invention

Steel blades as well as hard-tipped ceramic or soft-tipped elastomer blades are subject to dry friction against moving uncoated or precoated dry paper during the loading of the blade against the web. The time elapsed between the moment the blade comes into contact with the moving dry web and the arrival of the coating color at the blade is, depending on the paper machine, roughly between 1 and 5 seconds. With modern off-line coating machines, the web speed during the blade loading procedure can be as high as 700 m/min or above, which represents a dry friction length of 12 to nearly 60 meters.

Depending on the friction coefficient of the blade material, the blade loading angle or pressure against the web and the nature of the fibres and pigments of the base paper, dry friction can have dramatic consequences on the surface characteristics of the blade material. For instance the carefully ground bevels of the elastomer of a soft-tipped blade can be completely destroyed (burnt) during this step, and even the ceramic material of the hard-tipped blade can be marked with groves which may have a negative effect on the coating quality. This considerable initial wear will further reduce the lifetime of the blade. It is therefore highly desirable to prevent this damaging of the blade material so that

the high quality surface remains intact and available for the coating process.

Protection of the blade material from the dry friction may be achieved by lubricating the blade or the web during the loading procedure, e.g. by applying manually a lubricant onto the blade tip, or by spraying a lubricant solution directly onto the web such as for instance aqueous CMC solutions or aqueous solutions of copolymers used as rheology modifiers and water retention aids. However, this in turn requires the costly installation of a spray boom, a storage tank with pumps, or the like.

Objects of the invention

15 The main object of the invention is to provide means for reducing or eliminating dry friction between a blade and a travelling web during the web loading phase so as to increase the lifetime of the blade.

20 Another object of the invention is to provide such means residing in a coating blade for the application of coating color onto a travelling web while reducing or eliminating dry friction during the web loading phase.

25 Yet another object of the invention is to provide a coating blade provided with an edge section provided with a profile which is conformed to the surface of the web to be coated.

30 Still another object of the invention is to provide a method for preparing coating blades for the application of coating color onto a travelling web.

Summary of the invention

For these and other objects which will be clear to those skilled in the art from the disclosure to follow, the invention provides for a coating blade for the application of coating color onto a travelling web, said blade having an edge section with a profile conformed to the surface of said web when in engagement therewith. The

coating blade according the invention is characterised by a sacrificial layer covering at least said section and protecting the underlying edge section during the web loading phase.

5 It is preferred to use such coating blade for the application of an aqueous coating color, wherein said sacrificial layer is soluble in water and otherwise compatible with the coating color.

10 The sacrificial layer is preferably substantially non-hygroscopic so as to avoid otherwise rapidly increasing friction.

The sacrificial layer is suitably constituted by a material selected from water-soluble polymers and polysaccharides capable of forming a film.

15 The polysaccharides may be either natural polysaccharides or derivatives of natural polysaccharides.

Among natural polysaccharides there may be mentioned xanthan gum, guar gum, locust bean gum, pectines, 20 carageenans, dextrans, and polyuronides such as alginates.

25 Among derivatives of natural polysaccharides there may be mentioned cellulose derivatives, such as carboxymethylcellulose (CMC), hydroxyethylcellulose (HEC), methylcellulose (MC), methylhydroxyethylcellulose (MHEC), and hydroxypropylcellulose (HPC).

Other derivatives are starch derivatives, such as soluble starch, hydroxyethylstarch, hydroxypropylstarch, cationic starch, and dextrins.

30 Among water soluble polymers there may be mentioned acrylic-and methacrylic-polymers and -copolymers, such as poly(meth)acrylic acid, poly(meth)acrylates, polyacryl amide, copolymers of acrylamide and (meth)acrylic acid or (meth)acrylates, copolymers of (meth)acrylic acid, (meth)acrylates and acrylonitrile.

35 Other water soluble polymers are vinylic and allylic polymers, such as polyallylamines and salts,

polyvinylalcohol, polyvinylpyridine and derivatives, polyvinylpyrrolidone, polyvinylmethylether, poly(styrenesulfonic acid) and salts, copolymers of styrenesulfonic acid and maleic acid and their salts.

5 Other polymers that may be used are polyethyleneimine, polyethyleneglycol, polyethyleneoxide, and poly(2-ethyl-2-oxazoline).

10 It is preferred that the polymers and polysaccharides used are film-forming so as to give a sacrificial layer constituted by a film.

15 Among preferred water-soluble polymers there may be mentioned acrylamide polymers and copolymers.

20 Among useful polysaccharides there may be mentioned hemi-cellulose, plant gums, cellulose and derivatives thereof, starch and derivatives thereof, microbial polysaccharides, algal polysaccharides, and chitosan and derivatives thereof.

Preferred polysaccharides are ethyl cellulose, hydroxyethyl cellulose and carboxymethyl cellulose.

25 The coating blade substrate carrying the sacrificial layer constituting the essential feature of the present invention can be any type of substrate, such as steel, steel carrying a ceramic coating and so called soft tipped blades. An example of steel substrate is carbon steel, quality UHB®, 20 C (Uddeholm, Sweden). Coating blades provided with a ceramic coating are disclosed in GB 2 130 924. Finally, so called soft tipped blades are disclosed in EP 0 944 438, and the preferred soft material is polyurethane.

30 The invention also provides for a method for preparing a coating blade for the application of coating color onto a travelling web, said blade having an edge section with a profile conformed to the surface of said web when in engagement therewith, said method comprising 35 the following steps:

a) preparing a solution containing a material capable of forming a film on evaporation of the solvent;

- b) applying said solution onto at least said section; and
- c) allowing the applied solution to dry so as to form a solid film on at least said section.

5 Step c) preferably includes heating to an elevated temperature, and the coating solution is suitably applied in several layers with intermediate heating between the application of each layer.

10 To protect the blade material from dry friction the sacrificial layer is integrated in the blade concept, and applied after grinding of the blade material into the desired geometry and surface smoothness. Application of the sacrificial layer can thus be made as a final manufacturing step. The function of the sacrificial layer 15 will be to wear down during the blade loading procedure and then disappear completely with arrival of the coating color, leaving the original blade geometry and surface quality. The requirements of such sacrificial layer can thus be summarised as follows:

20 The layer shall have a low friction coefficient against the travelling web, such as uncoated or precoated dry paper, and have the ability to absorb the energy of friction without melting or turning into a sticky condition;

25 The layer shall have good film-forming properties, show good adhesion onto the blade material, and have sufficient mechanical strength to withstand loading constraints;

30 Furthermore, the layer shall have good solubility in the coating color medium (such as good water solubility without being hygroscopic) so as to disappear as quickly as possible once the coating color has reached the blade;

The layer shall have good compatibility with, and be non-polluting towards the coating color.

Detailed description of the invention

5 Preferred sacrificial layer materials are water-soluble polymers such as acrylic copolymers or soluble cellulose derivatives. These polymers are preferentially applied as an aqueous solution in a continuous way onto the ground blade material and hot air-dried in a
10 controlled manner to give a smooth, non-sticky dry layer. This operation can be done on 100 m coils of the blade after grinding into the desired geometry and before cutting into the desired blade length. The solutions can be applied by different techniques such as roll coating,
15 blade coating, flow coating, casting, spraying, dipping, etc. The desired layer thickness after drying can be adjusted either through the concentration or viscosity of the solution, or by applying successive layers of the solution with intermediate drying of each individual
20 layer. The required sacrificial layer thickness is a function of the blade loading conditions of the paper machine, e.g. web speed, loading angle (blade pressure), and of the paper quality (pulp, pigments etc.). A thickness in the range of 100 μm to 700 μm is sufficient
25 for most loading conditions.

The following examples further illustrate the invention by specific embodiments thereof. It should be noted, however, that the invention is not restricted to these examples.

30

Example 1

This and following examples No 2-6 relate to the application of a protective sacrificial layer on a soft-

tipped coating blade such as described in US 6,312,520 B1 and prepared according to EP 1 156 889. An aqueous solution of an anionic copolymer on the basis of Acrylic acid, Acrylic ester, and Acrylonitrile such as Sterocoll 5 SL (BASF) containing 25% of solids, is applied onto the moving blade coil by means of a 0.152 mm thick steel trailing blade in such a way to form a continuous regular wet film covering the soft-tipped coating blade material, particularly the ground bevels. The water soluble 10 copolymer is applied at a rate of 2.5 g/min using a dosing pump while the coating blade coil is moving at a speed of 1 m/min. The moving blade coil with the wet film is passed through a hot air tunnel to evaporate most of the water before it is wound up with a spacer and dried 15 in a hot air oven at 60°C for 2h. The tacky free shiny layer obtained this way has an average thickness of 90µm.

Example 2

The procedure of example 1 is repeated several times 20 using each time the same coating blade coil with the applied protective layer(s), so as to build up a multilayer protective film, adding a thickness of 90µm to each previous layer. Thus a 2 layer film had a thickness of 180µm, and a 5 layer film 450µm.

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Example 3

A 25% aqueous solution of Sterocoll SL (BASF) was applied onto the moving coating blade coil in a similar way as in example 1 with the difference that no trailing 30 blade was used to adjust the thickness, and the application rate was 18 g/min. After drying, the film thickness was 650µm.

Example 4

A 5% aqueous solution of medium viscosity Hydroxyethylcellulose (Fluka Chemie, Switzerland) was applied onto the moving coating blade coil in a similar 5 way as in example 1 with the difference that no trailing blade was used to adjust the thickness, and the application rate was 24 g/min. After drying, the film thickness was 170 μ m.

10 Example 5

A 2% aqueous solution of medium viscosity Carboxymethylcellulose (Fluka Chemie, Switzerland) was applied onto the moving coating blade coil in a similar way as in example 1 with the difference that no trailing 15 blade was used to adjust the thickness, and the application rate was 24 g/min. After drying, the film thickness was 70 μ m.

Example 6

20 A 25% aqueous solution of Sterocoll SL (BASF) was applied onto the moving coating blade coil at a rate of 19 g/min and a coil speed of 2 m/min and using a doctor knife to adjust the thickness. After drying, the film thickness was between 300 and 350 μ m.

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Example 7

This and following example 8 relate to the efficiency of the sacrificial layer in protecting the coating blade material against the consequences of dry 30 friction. An industrial pilot coater (Beloit S-matic) was used for this purpose: the coating blade with its sacrificial layer was loaded against uncoated paper (mechanical pulp, 48 g/m²) and without coating color,

under various conditions of loading angle, pressure, web speed and time. Different conditions of dry friction between the coating blade and the travelling web are realized in this way. After the test, the residual 5 sacrificial layer of the blade is then removed by dissolution in water, and the width of the blade bevel compared to the original bevel of a reference blade without sacrificial layer. In this example, the sacrificial layer was applied to the coating blades under 10 conditions of example 3, providing a protective film having a thickness of 650 mm.

Trial No	Duration [s]	Speed [m/mn]	Loading angle	Pressure [bar]	Width of bevel (after removal of the residual sacrificial layer)
1	6	100	1.5	0.75	550µm
2	13	100	1.5	0.60	550µm
3	13	300	1.5	0.25	550µm
4	13	300	3.0	0.64	550µm
5	13	500	5.0	1.21	575µm
6	13	300	3.0	0.58	575µm
7	13	700	3.0	0.45	650µm
Ref	---	---	---	---	550µm

Table 1: Dry friction tests

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Results of table 1 show that a 100% protection of the soft-tipped blade bevel was realized under conditions of trials No 1-4. In trials No 5 and 6, the increase of web speed and blade pressure was such that the 20 sacrificial layer was worn away and the width of the blade bevel was very unsignificantly increased (+25 µm), still providing a good protection of the blade. Trial No 7 shows the limiting loading conditions where the blade protection is no more assured.

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Example 8

In this example, the sacrificial layer was applied to the coating blade under conditions of example 4, providing a protective film layer with a thickness of 5 $70\mu\text{m}$. The blades were tested with the same equipment, raw materials, and under similar conditions as mentioned in example 7. Results in table 2 demonstrate a good blade protection under conditions of trials No 8-11, whereas under the condition of trial No 12, a good protection is 10 no more assured.

Trial No	Duration [s]	Speed [m/mn]	Loading Angle	Pressure [bar]	Width of bevel (after removal of the residual sacrificial layer)
Ref	---	---	---	---	$550\mu\text{m}$
8	13	100	1.5	0.15	$550\mu\text{m}$
9	13	300	3.0	0.61	$550\mu\text{m}$
10	13	300	5.0	1.23	$550\mu\text{m}$
11	13	500	3.0	0.58	$550\mu\text{m}$
12	13	700	3.0	0.38	$675\mu\text{m}$

Table 2: Dry friction tests

Example 9

This example relates to the use of the coating blade of the invention under industrial coating conditions and a comparison with a standard coating blade. Trials are performed on a pilot board coater equipped with an ABC 15 blade holder: precoated board of 260 g/m^2 was used with a web speed of 450 m/min and coating color having a solids content of 64%. The coating blades used for these trials 20 were of the soft-tip type and were protected with a sacrificial layer of $300\mu\text{m}$ thickness, prepared according to example 6. During loading of the blade, and before 25 arrival of the coating color, the blades were submitted

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to dry friction against the moving board. After coating of the reel, the coating blade was taken out of the blade holder for examination. A reference trial with a similar blade but without sacrificial layer was run under identical conditions for comparison. Results in table 3 clearly show the benefit of the protective sacrificial layer. Examination of blades from trials 1-4 after coating one reel revealed that no residual traces of sacrificial layer were left, i.e. all unused film material had been dissolved by the coating color, and that there was no damage due to dry friction. On the other hand, the reference trial had to be interrupted because of large streaks in the coating as a result of blade damage coming from dry friction.

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Trial No	Dry friction [sec]	Sacrificial layer	Coating quality	Blade surface
1	5	300µm	Good	Undamaged
2	10	300µm	Good	Undamaged
3	15	300µm	Good	Undamaged
4	25	300µm	Good	Undamaged
Ref	15	No	Bad→Streaks	Damaged

Table 3: Pilot coating trials

CLAIMS

1. Coating blade for the application of coating color onto a travelling web, said blade having an edge section with a profile conformed to the surface of said web when in engagement therewith,
characterized by a sacrificial layer covering at least said section and protecting the underlying edge section during the web loading phase.
2. Coating blade according to claim 1 for use in the application of an aqueous coating color, wherein said sacrificial layer is soluble in water and otherwise compatible with said coating color.
3. Coating blade according to claim 1 or 2, wherein said sacrificial layer is substantially non-hygroscopic.
4. Coating blade according to any one of the preceding claims, wherein said sacrificial layer is constituted by a material selected from water-soluble polymers and polysaccharides capable of forming a film.
5. Coating blade according to claim 4, wherein said material is selected from acrylic or methacrylic polymers and copolymers and their salts.
6. Coating blade according to claim 4, wherein said material is selected from anionic copolymers on the basis of Acrylic acid, Acrylic ester and Acrylonitrile.
7. Coating blade according to claim 4, wherein said material is selected from film-forming polysaccharides.
8. Coating blade according to claim 7, wherein said material is selected from hemi-celluloses, plant gums, cellulose and derivatives thereof, starch and derivatives thereof, microbial polysaccharides, algal polysaccharides, and chitosan and derivatives thereof.
9. Coating blade according to claim 8, wherein said material is selected from ethyl cellulose, hydroxyethyl cellulose and carboxymethyl cellulose.
10. Coating blade according to any one of the preceding claims selected from steel blades, blades having a ceramic tip, and soft tipped blades.

11. A method of preparing a coating blade for the application of coating color onto a travelling web, said blade having an edge section with a profile conformed to the surface of said web when in engagement therewith,
5 comprising the following steps:

- a) preparing a solution containing a material capable of forming a film on evaporation of solvent;
- b) applying said solution onto at least said section; and

10 c) allowing the applied solution to dry so as to form a solid film on at least said section.

12. A method according to claim 11, wherein step c) includes heating to an elevated temperature.

13. A method according to claim 11 or 12, wherein
15 the solution is applied in several layers with intermediate heating between the application of each layer.

14. A method according to any one of the claims 11 to 13, wherein under step a) an aqueous solution is
20 prepared which contains a polysaccharide in a concentration of at most about 10% by weight.

15. A method according to claim 14, wherein said concentration is from about 1% to about 7% by weight.

16. A method according to any one of the claims 11
25 to 13 wherein under step a) an aqueous solution is prepared which contains an anionic copolymer on the basis of acrylic acid, acrylic ester and acrylonitrile in a concentration of at most about 40% by weight.

17. A method according to claim 16, wherein said
30 concentration is about 15% to about 30%.